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Minnesota logging utilization factors, 1975-1976— development, use, implications

James E. Blyth and W. Brad Smith

North Central Forest Experiment Station
Forest Service, U.S. Department of Agriculture

North Central Forest Experiment Station
Robert A. Hann, Director
Forest Service - U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108

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FOREWORD

As the demand for forest products intensifies and the resulting pressure on forest resources grows, the need for accurate information on the quantity and kinds of trees required to provide these products increases.

For more than two decades, the trend has been toward using more of the harvested tree and leaving less logging residue in the woods. Total tree chipping, still in its infancy in the north-central region, was the greatest breakthrough in increasing the utilization of trees for products. In total tree chipping, all of the tree is chipped and used, except the stump, roots, and occasional branches that break off when the trees are forwarded to the chipper.

As the utilization of trees improves, fewer trees need to be harvested for a given quantity of products. Without up-to-date logging utilization factors, timber requirements for products would be overestimated and knowledge would be incomplete and inaccurate about the quantity and kinds of logging residue. In addition, the proportions of different kinds of trees harvested (such as poletimber and sawtimber) changes. Consequently, we cannot accurately project future timber stand conditions and composition without current utilization factors.

In 1975-1976, at the same time as the latest Minnesota forest inventory was conducted, we completed a study to determine Minnesota logging utilization factors for saw logs and pulpwood. New factors were needed to replace outdated factors from a study in 1960-1961. The factors were determined per thousand board feet of saw logs and per cord of pulpwood cut. This study concentrated on saw log and pulpwood factors because these products accounted for 81 percent of all Minnesota forest products harvested in 1975 and 94 percent of all products cut for forest industry.

For the first time, logging utilization factors were determined for total tree chipping as well as separate utilization factors for conventional logging. These factors are used primarily to estimate the quantity and kinds of timber cut to provide the products for a specific year.

Technical terms in this paper are defined in the Appendix.

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MINNESOTA LOGGING UTILIZATION FACTORS, 1975-1976—DEVELOPMENT, USE, IMPLICATIONS

James E. Blyth, *Principal Market Analyst,*
and **W. Brad Smith,** *Associate Mensurationist*

RESULTS

Saw Logs

Logging utilization factors for saw logs were developed for five species groups—white and red pine, other softwoods, aspen, other soft hardwoods, and hard hardwoods. For each species group, 95 percent or more of the saw log volume comes from growing stock; the remainder is from nongrowing stock such as tops and limbs of growing stock trees, cull trees, and cull logs.

For each species group, except aspen, 92 percent of the saw log volume from growing stock came from the saw log portion of sawtimber growing stock trees (table 1). Aspen saw log output is distinctly different. One-fifth comes from poletimber, an indication of the strong competition for aspen that pulpmills have experienced from sawmills.

Growing stock logging residue is four to five times higher per unit of logs produced for soft hardwoods and hard hardwoods than for aspen and softwoods. Lack of markets for mixed hardwood pulpwood in Minnesota may be the cause.

More than 50 cubic feet of nongrowing stock residue is generated per thousand board feet of "other soft hardwood" and red and white pine saw logs cut. Most of the nongrowing stock logging residue is in tops and limbs. Excluding aspen, hardwood cull trees and logs are significant sources of nongrowing stock residue.

Less logging residue is created per unit of log output in aspen than in any other species group. Well-developed markets for joint products—aspen pulpwood and saw logs—may be the key reason for the low residue production.

Per thousand board feet of log output, less growing stock (in cubic feet) is cut from white and red pine than for any other species group. This reflects the large high quality trees being harvested and good markets for pine saw logs.

Pulpwood-Conventional Logging

Pulpwood factors for conventional logging were established for four species groups—pine, other softwoods, aspen, and other hardwoods. For each species group, 88 percent or more of the conventional pulpwood comes from growing stock (table 2). On a per cord basis, more growing stock is used in softwoods than in hardwoods.

For softwoods and aspen, more than half of each cord comes from sawtimber trees; the saw log portion contributed 30 cubic feet or more per cord. Heavy use of the saw log portion indicates very competitive markets with sawmills because saw logs come primarily from the same source.

Only one-sixth of each cord from other hardwoods is from sawtimber. Because pulpwood markets are weak for other hardwoods, the pulpmills apparently can procure their requirements of other hardwoods without competing with sawmills for sawtimber. About three-fourths of the pulpwood from other hardwoods is cut from pole-timber compared to approximately one-third in other species groups.

Aspen cull trees and cull logs are an important source of pulpwood. Tops and limbs of growing stock trees are the primary source of pulpwood from nongrowing stock in other species groups.

Logging residue ranges from 10.8 cubic feet generated per cord of pulpwood in other softwoods to 16.1

Table 1.—*Volume of timber cut to provide 1,000 board feet[1] of saw logs, Minnesota, 1975-1976*
(In cubic feet)

Source of timber cut	White and red pine	Other soft-woods	Aspen	Other soft hard-woods	Hard hard-woods
Timber product output:	172.7	192.1	185.3	176.0	168.2
From growing stock:	170.4	184.6	182.0	167.8	163.4
Sawtimber trees:	168.4	178.6	145.7	157.6	162.9
Saw log portion	166.6	176.4	134.7	155.1	152.6
Upper stem	1.8	2.2	11.0	2.5	10.3
Poletimber trees	2.0	6.0	36.3	10.2	0.5
From nongrowing stock:	2.3	7.5	3.3	8.2	4.8
Tops and limbwood[2]	1.8	7.4	2.1	4.7	1.1
Cull trees and logs[3]	0.5	0.1	1.2	3.5	3.7
Saplings	0.0	0.0	0.0	0.0	0.0
Dead trees[3]	0.0	0.0	0.0	0.0	0.0
Nonforest land	0.0	0.0	0.0	0.0	0.0
Logging residue:	57.4	29.0	24.4	93.4	61.6
From growing stock:	5.2	5.4	5.7	33.6	23.8
Sawtimber trees:	5.2	5.1	4.6	33.0	23.8
Saw log portion	1.9	0.8	0.5	19.0	8.4
Upper stem	3.3	4.3	4.1	14.0	15.4
Poletimber trees	0.0	0.3	1.1	0.6	0.0
From nongrowing stock:	52.2	23.6	18.7	59.8	37.8
Tops and limbwood[4]	51.8	23.6	18.1	51.0	29.1
Cull trees and logs[5]	0.4	0.0	0.6	8.8	8.7
Saplings	0.0	0.0	0.0	0.0	0.0
Dead trees[5]	0.0	0.0	0.0	0.0	0.0
Nonforest land	0.0	0.0	0.0	0.0	0.0
Total timber cut:	230.1	221.1	209.7	269.4	229.8
From growing stock	175.6	190.0	187.7	201.4	187.2
From nongrowing stock	54.5	31.1	22.0	68.0	42.6

[1]International ¼-inch log rule.
[2]Includes tops, limbs, and stumpwood of growing stock trees.
[3]Includes tops, limbs, and stumpwood as well as bolewood.
[4]Includes tops and limbs in growing stock trees and limbs in nongrowing stock trees. Does not include stumpwood.
[5]Includes tops but not limbs.

cubic feet per cord in aspen. One-fifth or less of the residue is growing stock—most of it is tops and limbs.

For all species, less than a cord of growing stock is cut per cord of pulpwood. Pulpwood cut from nongrowing stock more than offsets the logging residue from growing stock. Aspen requires the least growing stock cut per cord of pulpwood. However, the total timber cut per cord is highest in aspen and, consequently, the most residue is created from aspen.

Pulpwood-Total Tree Chipping

Minnesota total tree chips currently are a minor source of pulpwood but will probably become more important, particularly if chips are used both for pulpwood and fuelwood. Saw logs rarely were cut and separated out during total tree chipping in Minnesota in 1976. More than 95 percent of the chips produced in Minnesota are aspen.

The major advantage of total tree chipping over conventional logging is that less growing stock is cut per cord of pulpwood. Only 61.3 cubic feet of growing stock is cut to produce a cord of total tree chips compared to 72.1 cubic feet of aspen growing stock cut per cord of conventional pulpwood. Tops, limbs, and stumpwood of growing stock trees, cull trees, and cull logs provide most of the nongrowing stock total tree chips.

Table 2.—*Volume of timber cut to provide one cord of pulpwood, Minnesota, 1975-1976*
(In cubic feet)

Source of timber cut	Conventional logging				Total tree chipping (all species)[1]
	Pine	Other soft-woods	Aspen	Other hard-woods	
Timber product output:	79.0	79.0	79.0	79.0	79.0
From growing stock:	73.6	75.2	69.2	71.8	61.3
Sawtimber trees:	46.5	48.4	41.9	13.0	27.2
Saw log portion	32.0	41.5	30.3	9.2	21.1
Upper stem	14.5	6.9	11.6	3.8	6.1
Poletimber trees	27.1	26.8	27.3	58.8	34.1
From nongrowing stock:	5.4	3.8	9.8	7.2	17.7
Tops and limbwood[2]	4.1	3.1	1.0	4.3	10.2
Cull trees and logs[3]	1.1	0.6	7.2	2.9	7.1
Saplings	0.0	0.1	0.0	0.0	0.2
Dead trees[3]	0.2	0.0	1.6	0.0	0.2
Non-forest land	0.0	0.0	0.0	0.0	0.0
Logging residue:	12.0	10.8	16.1	15.3	0.0
From growing stock:	1.1	1.3	2.9	3.1	0.0
Sawtimber trees:	0.5	0.5	1.5	0.1	0.0
Saw log portion	0.0	0.0	0.3	0.0	0.0
Upper stem	0.5	0.5	1.2	0.1	0.0
Poletimber trees	0.6	0.8	1.4	3.0	0.0
From nongrowing stock:	10.9	9.5	13.2	12.2	0.0
Tops and limbwood[4]	10.5	9.5	12.7	11.5	0.0
Cull trees and logs[5]	0.0	0.0	0.4	0.7	0.0
Saplings	0.1	0.0	0.0	0.0	0.0
Dead trees[5]	0.3	0.0	0.1	0.0	0.0
Nonforest land	0.0	0.0	0.0	0.0	0.0
Total timber cut:	91.0	89.8	95.1	94.3	79.0
From growing stock	74.7	76.5	72.1	74.9	61.3
From nongrowing stock	16.3	13.3	23.0	19.4	17.7

[1]More than 95 percent aspen.
[2]Includes tops, limbs, and stumpwood of growing stock trees.
[3]Includes tops, limbs, and stumpwood as well as bolewood.
[4]Includes tops and limbs in growing stock trees and limbs in nongrowing stock trees. Does not include stumpwood.
[5]Includes tops but not limbs.

Use of Results—Timber Harvest Estimates

The quantity of saw logs and pulpwood produced in 1975 in Minnesota was estimated from another study of primary wood-using mills (those using logs and bolts). The quantity of timber harvested (from poletimber, sawtimber, etc.) was estimated by multiplying the appropriate logging utilization factors times the estimated volume of saw logs and pulpwood produced in 1975. Based on these factors, 68.9 million cubic feet of aspen was harvested in 1975 for saw logs and pulpwood (table 3). Of this total 84 percent went into products and 16 percent was residue. Other species groups compared are pine, other softwoods, and other hardwoods.

Within these groups, striking differences are found in timber utilization on a proportional basis. More of the softwood timber cut is growing stock compared to hardwoods. The degree of tree utilization and growing stock utilization for products was highest for other softwoods followed in order by pine, aspen, and other hardwoods. More than one-fourth of the other hardwood harvest was logging residue. Sawtimber trees were a more important product source in pine than in the other species groups. More poletimber in

aspen and other softwoods is utilized compared to pine and other hardwoods. Aspen nongrowing stock was twice as important as a product source as nongrowing stock in the other groups.

For all species groups, except other hardwoods, total product output was higher than the quantity of growing stock cut. In these groups, use of nongrowing stock for products more than offset the logging residue from growing stock. Because sawmills have less competition from pulpmills for other hardwoods, timber product output from these hardwoods was 6.5 percent less than the growing stock harvest. One-third of the logging residue in other hardwoods was growing stock.

Another 309,000 cords of products could have come from logging residue in 1975. By species group, the volume was:

Species group	Logging residue (Thousand cords)
Pine	57
Other softwoods	55
Aspen	141
Other hardwoods	56

More than three-fourths of the logging residue was in tops and limbs.

Table 3.—*Volume and percent of timber cut for pulpwood and saw logs in Minnesota, 1975*

Source of timber cut	Volume				Percent			
	Pine	Other softwoods	Aspen	Other hardwoods	Pine	Other softwoods	Aspen	Other hardwoods
	Thousand cubic feet							
Timber product output:	25,056	31,880	57,826	12,305	84.9	87.9	83.9	73.3
From growing stock:	23,730	30,367	51,631	11,650	80.4	83.7	74.9	69.4
Sawtimber trees:	18,127	20,141	33,021	8,047	61.4	55.5	47.9	48.0
Saw log portion	15,143	17,496	25,334	7,550	51.3	48.2	36.8	45.0
Upper stem	2,984	2,645	7,687	497	10.1	7.3	11.1	3.0
Poletimber trees	5,603	10,226	18,610	3,603	19.0	28.2	27.0	21.4
From nongrowing stock:	1,326	1,513	6,195	655	4.5	4.2	9.0	3.9
Tops and limbwood[1]	1,060	1,249	718	361	3.6	3.5	1.0	2.2
Other[2]	266	264	5,477	294	0.9	0.7	8.0	1.7
Logging residue:	4,473	4,382	11,123	4,466	15.1	12.1	16.1	26.7
From growing stock:	485	543	2,070	1,506	1.6	1.5	3.0	9.0
Sawtimber trees:	357	235	1,149	1,318	1.2	0.6	1.7	7.9
Saw log portion	63	5	204	642	0.2	([3])	0.3	3.8
Upper stem	294	230	945	676	1.0	0.6	1.4	4.1
Poletimber trees	128	308	921	188	0.4	0.9	1.3	1.1
From nongrowing stock:	3,988	3,839	9,053	2,960	13.5	10.6	13.1	17.7
Tops and limbwood[4]	3,905	3,839	8,718	2,544	13.2	10.6	12.6	15.2
Other[5]	83	—	335	416	0.3	—	0.5	2.5
Total timber cut:	29,529	36,262	68,949	16,771	100.0	100.0	100.0	100.0
From growing stock	24,215	30,910	53,701	13,156	82.0	85.2	77.9	78.4
From nongrowing stock	5,314	5,352	15,248	3,615	18.0	14.8	22.1	21.6

[1]Includes tops, limbs, and stumpwood of growing stock trees.
[2]Cull trees and logs, saplings, and dead trees.
[3]Less than 0.05 percent.
[4]Includes tops and limbs in growing stock trees and limbs in nongrowing stock trees. Does not include stumpwood.
[5]Cull trees and logs, saplings, and dead trees. Includes tops but not limbs or stumpwood.

STUDY LIMITATIONS

Limbwood logging residue estimates from conventional logging and all limbwood estimates from total tree chipping depended on the accuracy of the regression equations that estimated total tree wood fiber (excluding the standard 1-foot stump). The equations provide good approximations but are being further refined and tested. Readers are cautioned to place less confidence in these limbwood data than in other measured data.

Logging residue was assigned to the major product from a tree rather than proportionally by product volume from the tree. Therefore, logging residue estimates assigned to saw logs and pulpwood vary slightly from what would have been determined by proportional allocation to joint products.

It is not practical or economical to measure utilized stumpwood or bolewood sections less than 6 inches long. Consequently, bolewood and utilized stumpwood are slightly underestimated.

STUDY METHODS

Conventional Logging

Sixty-five active logging operations were visited during 1975-1976, and 768 sample trees cut for pulpwood and saw logs were measured immediately after they were felled. The sample volume to be measured was allocated to the four Minnesota Survey Units according to the estimated annual volume of saw logs and pulpwood cut in each Unit from each species group (fig. 1). At least 1,000 cubic feet of sample was measured in each pulpwood species group and 1,100 cubic feet in each saw log species group (table 4). The sample volume included all growing stock in a sample tree plus all nongrowing stock from that tree that was used for pulpwood or saw logs. Saw log and pulpwood volumes in the sample were recorded in their respective product categories and growing stock logging residue was assigned to the major product cut from the tree. For example, if more saw log volume was cut from a tree than pulpwood, the growing stock logging residue was credited to the saw log sample requirement.

Because the degree of tree utilization can vary between public and private land, the sample proportion for each owner class in each Survey Unit was approximately the portion of commercial forest land in that owner class for that Unit.

Logging operations were found by talking to public timber sale administrators, sawmill operators,

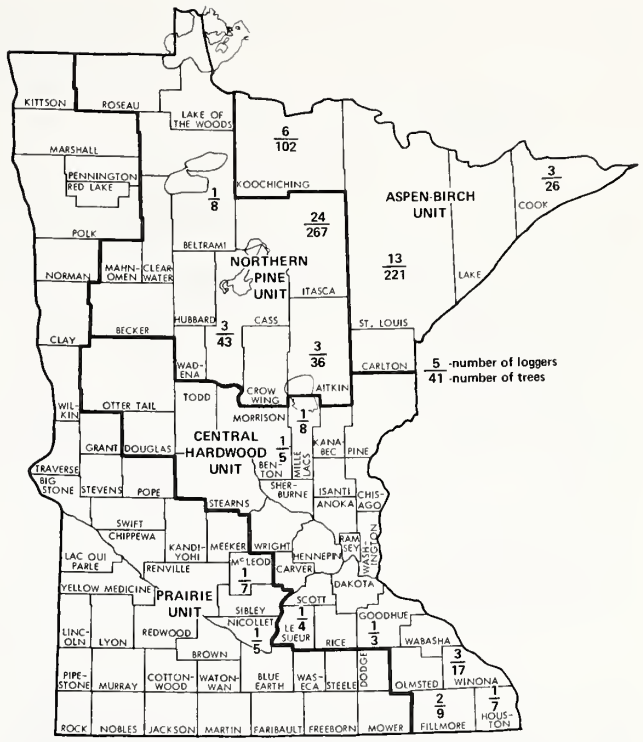

Figure 1.—*Survey Units in Minnesota and number of loggers and trees sampled during conventional logging.*

pulpwood procurement personnel, and others knowledgable about logging operations in a given area. At each logging operation, sample felled trees were measured until approximately 200 cubic feet of sample was measured or until the logging was completed, whichever occurred first. The last sample tree on an operation was completely measured even though, as a result, the sample total went above 200 cubic feet.

Large logging operations were those using feller-bunchers, or those using several fellers, and the number of felled trees generally exceeded 10 at any given time. On large operations, every fifth tree per feller was measured and the sample volume per feller was limited to approximately 200 cubic feet divided by the number of fellers.

On small logging operations, where the number of felled trees seldom exceeds 10 at any given time, all felled trees were sampled until the required volume was measured.

Each tree was classified as live merchantable (poletimber or sawtimber), sapling, cull, or dead. Tree origin was classed as commercial forest or nonforest land and the species and diameter at breast height (d.b.h.) was recorded. Each section of bolewood was classed as a product or logging residue and as

Table 4.—*Minimum volume*[1] *of sample felled trees to be measured by product and species group in each Survey Unit (conventional logging operations only)*
(In cubic feet)

Products	Survey Unit				State total
	Aspen-birch	Northern pine	Central hardwood	Prairie	
Saw logs:	1,120	3,870	1,960	450	7,400
White and red pine	510	1,190	—	—	1,700
Other softwoods	280	820	—	—	1,100
Aspen	200	920	80	—	1,200
Other soft hardwoods	130	510	760	300	1,700
Hard hardwoods	—	430	1,120	150	1,700
Pulpwood:	2,720	1,670	110	—	4,500
Pine	630	370	—	—	1,000
Other softwoods	660	340	—	—	1,000
Aspen	810	580	110	—	1,500
Other hardwoods	620	380	—	—	1,000

[1]Total volume is the volume of growing stock cut plus the volume of products cut from nongrowing stock.

growing stock or nongrowing stock (fig. 2). After classification, the length and diameter inside bark (at each end) of each section was measured. Limbwood used for products was similarly measured. Total wood fiber in each tree was estimated from regression equations using d.b.h. as an independent variable. Limbwood logging residue was estimated by subtracting the measured tree volume from the estimated wood fiber volume in the tree.

Total Tree Chipping

During the study period, five logging firms were producing total tree chips. A minimum of 700 cubic feet of sample was measured at each of these logger's operations with the sample for each logger equally divided among three logging sites to reduce sample bias at one site. Only the bolewood counted toward the minimum sample volume of 233 cubic feet per logging site. By county, the number of sample trees was:

County	Number of Trees
St. Louis	172
Aitkin	46
Itasca	42

Of the total sample of 260 trees, 253 were aspen.

Trees were measured after they were piled in bunches prior to delivery to the chipharvester. Not more than five trees per pile were measured, and the trees selected were those that could be moved and measured. If more than five trees could be measured in a pile, the sample trees were selected randomly (using a table of random numbers).

Sample piles were selected using a random start system so the sample was spread about equally geographically over the logging area.

Tree classification, species, and measurement data were similar to those collected in conventional logging, except no limbwood was measured and, from a practical viewpoint, no logging residue was generated. The limbwood volume used for pulpwood was estimated by subtracting total bolewood volume from the total wood fiber volume estimated by the regression equations. Occasionally saw logs were cut from trees before the remainder was chipped. These logs were included in the conventional saw log sample volume.

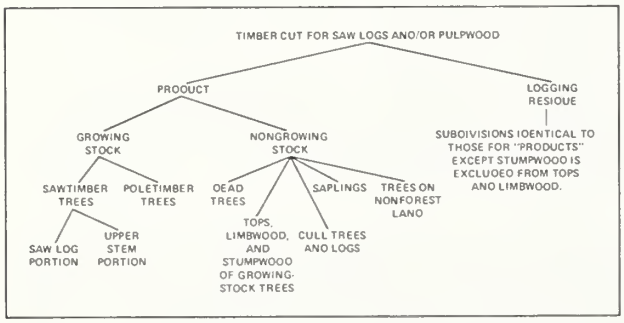

Figure 2.—*Flow chart showing potential sources of products and logging residue.*

APPENDIX

SAMPLING ERROR

All of the reported figures are estimates based on sampling procedures designed to give accurate estimates of growing stock cut in Minnesota for saw logs and pulpwood. A measure of reliability of these figures is given by sampling errors. These sampling errors may be interpreted as meaning that the chances are two out of three that the results for the sample differ, by no more than the amount indicated, from the results that would have been obtained if all trees in the State cut for pulpwood and saw logs had been measured.

Sampling errors for growing stock harvested per 1,000 board feet of saw logs and per cord of pulpwood cut are:

Type of logging	Sampling error (Percent)[1]
Conventional logging	
Saw logs:	
White & red pine	2.88
Other softwoods	1.68
Aspen	2.22
Other soft hardwoods	6.32
Hard hardwoods	2.57
All species	1.01
Pulpwood:	
Pine	1.89
Other softwoods	1.54
Aspen	5.27
Other hardwoods	3.59
All species	1.50
Total tree chips	
All species	4.72

For white and red pine saw logs, the growing stock cut to provide 1,000 board feet of logs is 175.6 cubic feet and has a sampling error of ± 2.88 percent (± 5.1 cubic feet). The chances are two out of three that the growing stock harvested for those logs falls between 170.5 cubic feet and 180.7 cubic feet (175.6 ± 5.1), the limits within which the results of a 100-percent sample would occur.

[1] *At the 68-percent probability level.*

DEFINITIONS

Bolewood.—Wood fiber in the central stem of a tree.

Commercial forest land.—Forest land producing or capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Includes areas suitable for management to grow crops of industrial wood generally capable of producing in excess of 20 cubic feet per acre of annual growth. This includes both inaccessible and inoperable areas.

Cull trees.—Live trees that do not contain at least one merchantable 12-foot saw log or two noncontiguous 8-foot or longer saw logs, now or prospectively, because of roughness, poor form, or rot.

Growing stock.—Sawtimber and poletimber trees on commercial forest land.

Growing-stock volume.—Volume of sound wood in the bole of sawtimber and poletimber trees from a 1-foot stump to a minimum 4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

Hard hardwoods.—Dicotyledonous species with a hardness factor of 80 or more including white ash, green ash, yellow birch, hickory, hard maple, oak, and black walnut.

Limbwood.—Volume of sound wood in limbs of trees.

Logging residue.—The unused portions of trees cut for products.

Nonforest land.—Land that has never supported forests, and land formerly forested where forest use is precluded by development for nonforest uses, such as cropland, improved pasture, residential areas, and city parks. Also includes improved roads and adjoining rights-of-way, powerline clearings, and certain areas of water classified by the Bureau of Census as land. Unimproved roads, streams, canals, and nonforest strips in forest areas must be more than 120 feet wide, and clearings in forest areas must be more than 1 acre in size, to qualify as nonforest land.

Nongrowing stock.—Cull trees, dead trees, saplings, cull sections of growing stock trees, limbwood, tops, stumpwood, and timber on nonforest land.

Poletimber trees.—Live trees of commercial species on commercial forest land at least 5 inches in diameter at breast height but smaller than sawtimber size, and of good form and vigor.

Saplings.—Live trees of commercial species 1 inch to 4.9 inches in diameter at breast height and of good form and vigor.

Saw-log portion.—Net volume of growing stock in the bole of sawtimber trees from a 1-foot stump to a minimum 7 inches top diameter outside bark for softwoods and 9 inches for hardwoods.

Sawtimber trees.—Live trees of commercial species on commercial forest land containing at least a 12-foot saw log or two noncontiguous saw logs, each 8 feet or longer. At least 33 percent of the gross volume of the tree must be sound wood. Softwoods must be at least 9 inches d.b.h. and hardwoods at least 11 inches.

Soft hardwoods.—Dicotyledonous species with a hardness factor less than 80 including black ash, aspen, basswood, white birch, cottonwood, elm, hackberry, soft maple, balsam poplar, and willow.

Softwoods.—Coniferous species including northern white-cedar, balsam fir, jack pine, red pine, white pine, spruce, and tamarack.

Stumpwood.—Section of a growing stock tree bole from ground level to 1 foot above ground.

Tops.—Section of a growing stock tree bole above the 4-inch minimum diameter outside bark or above the point where the central stem breaks into limbs.

Upper stem.—Section of the bole of sawtimber trees above the saw-log portion to a minimum top diameter of 4 inches outside bark or to a point where the central stem breaks into limbs.

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KEY WORDS: Saw logs, pulpwood, growing stock, residue, total tree chips.

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Sing along with Woodsy and help stop pollution.